into the development and modernization of a nation, a simultaneous goal will be to convert nearly 37 percent of this energy consumption into electricity, again approximately the present Western European level.

Since it is extremely important to use Egypt's reserves of oil, natural gas, and coal for direct applications in industrial and agricultural production, such as steel, fertilizer, petro-chemicals and gasoline/diesel fuel, as well as for export, they should be used as little as possible for producing electricity. All electricity production should be based on nuclear energy and, where possible, hydro-electric projects; since the development of additional Egyptian hydro-electricity is limited, this means most future electricity will be nuclear-generated.

The total energy consumption in Egypt in the year 2020, taking into account this per capital goal and an expected population of about 90 million, is 362 GWt (Gigawatts thermal). Current total energy consumption (using 1978 data) based on approximately 40 million people is only 17.5 GWt. This means that total energy consumption (using 1978 data) based on approximately 40 million people is only 17.5 GWt. This means that total energy consumption must increase by over 20 times today's level. Of this total energy goal, 135 GWt must be used to produce electrical energy, meeting the goal of approximately 46 GWe (Gigawatt electric) consumed per year by 2020, assuming a thermal-to-electricity conversion efficiency rate of 35 percent.

Growth rates for electricity production are assumed to be somewhat higher than the total energy growth rate because of the former's importance in accelerating a nation's development. Between now and 1990, a 7 percent annual electricity growth rate is planned, while during the next decade through the year 2000, a 10 percent rate will be achieved. For the following two decades, the annual growth of electricity consumption will level off at about 8 percent. In order to produce the required amount of electricity, twice as much generating capacity must be installed, based on projected load factors for Europe and the United States.

Thus, using these growth rates and the capacity factor of 0.5, the electrical generating capacity will increase as follows: 3.2 GWe; 1990: 7.2 GWe; 2000: 18.7GWe; 2010: 42.0 GWe and 2020: 92 GWe.

Total energy growth begins with an average rate of 5 percent from now until 1990, and increasing to 8 percent in the last decade of this century. Between the year 2000 and 2010 an annual rate of 10 percent will be attained, dropping off again to 8 percent through 2020. Thus the total energy consumed in Egypt over this planning perod will increase as follows: 1980: 17.5 GWt; 1990 31 GWt; 2000: 67 GWt; 2010: 173 GWt and 2020: 362 GWt. Over one-third of this thermal energy is converted to electricity, and this ratio will continue to increase upwards of two-thirds by 2050. The remainder of thermal energy is to be used in direct applications, such as for fuel oil, gasoline, and industrial process heat.

Eighty to 85 GWe is to be provided by nuclear energy. A small amount of fossil-fuel-produced electricity is not expected to exceed 2 GWe total, and there will be a few GWe of hydro-electricity, inclding the Aswan Dam's full capacity of 2 GWe. Contributions from both these sources are not expected to exceed approximately 10 GWe by 2020.

How Oak Ridge began Mideast nuplex plans

by Robert Gallagher

The concept of the nuclear-centered agro-industrial complex ("nuplex") was originated by the scientists and statesmen who formulated President Eisenhower's 1953 Atoms for Peace program. The mid-50s Strauss-Eisenhower plan, named for the President and the first chairman of the Atomic Energy Commission, Adm. Lewis Strauss, called for construction of a nuplex in the Sinai-Negev area of the southeastern Mediterranean coast to be jointly owned and managed by Israel and Egypt.

In 1964, Oak Ridge National Laboratory set to working out the details of the nuplex idea for the Middle East and the entire developing sector of the world economy. Its efforts were spurred by the U.S. Senate's unanimous adoption of Senate Resolution 155, introduced in December 1967 by Senator Howard Baker. The resolution called for building peace in the Middle East through economic development centered around nuclear-based agricultural centers, whose waters would be provided by nuclear desalination plants.

> It is the sense of the Senate that the prompt design, construction and operation of nuclear desalting plants will provide large quantities of fresh water to both Arab and Israeli territories and thereby will result in: 1) new jobs for the many refugees; 2) an enormous increase in the agricultural productivity of existing wastelands; 3) a broad base for cooperation between the Israeli and Arab government(s); and 4) a further demonstration of the United States efforts to find peaceful solutions to areas of conflict.

The Oak Ridge scientists, led by Lab director Alvin M. Weinberg, approached their design studies by posing the question: "How can we most quickly bring the developing countries up to the standard of living of the advanced sector?" Their purpose and motivation was perfectly clear:

> (Nuplexes) would provide developing countries a means of combating the imminent food shortages as well as providing a means of "leapfrogging" in their development.[1]
>
> The time has come when the energy derived from nuclear energy can be looked upon very seriously as a key for releasing indigenous agriculture from the bondage imposed by the necessity of securing fuel, fertilizer, and power for tillage all directly from the land without energy resources from the outside. . . . Such inputs could free these peoples from the Malthusian limitations hitherto imposed upon their indigenous food supply. . . .[2]

The Oak Ridge team developed detailed economic blueprints for some 26 nuplex sites around the world. Central to their application of nuclear power to developing sector agriculture was the use of power-intensive processes to obviate the need for raw materials such as naphtha and sulfur for fertilizer production. They also produced designs for nuplex-based production of magnesium, acetylene, aluminum, and many other products; special emphasis was devoted to nuplex steel-making.

The agricultural section of Oak Ridge's main conceptual study takes the Strauss-Eisenhower Sinai-Negev site as an exemplary design for a "food factory" that, depending on crop mixture and patterns, could support between 4.5 and 6.2 million persons, at a cost no greater than 9 cents per day per person in 1967. Water usage per person for this food factory would be equivalent to per person wate usage in New York City. The study details water usage, yields, food value, and efficiency for some 10 crops and three principal crop mixes. The team rigorously calculated internal rates of return for both agricultural and industrial production, which demonstrated that the nuplexes would make a profit as high as 19 percent and that the vast Egyptian domestic market was ideal for assimilating nuplex agricultural goods.

A central feature of the Oak Ridge program was to apply nuclear-based desalination to provide irrigation water and reclaim first coastal, then inland, deserts throughout the developing sector—directly following the model of America's own development.

> A third of the world's land is dry and virtually unoccupied, while half of the world's people are jammed—impoverished and undernourished—into a tenth of the land area. . . . [T]he fastest-growing region in our own country is the southwest desert, into which Americans move happily, taking their water and power requirements with them. . . . [N]uclear energy—not tied by any "umbilical cord" to coal or petroleum deposits—will play a significant role in opening up arid areas for human living space.[3]

A central feature was the expansion of educational institutions to train the skilled labor required to run the nuplexes after a period of transition. They saw that the nuplex would have to be prepared for the introduction of revolutionary new technologies at least every 15 years. They projected a two-phase nuplex program, the first based on light-water reactors and the second on advanced nuclear-fuel breeder reactors. Due to the stagnation of advanced-sector industrial development, virtually the same technologies that were on the drawing boards during the studies are still there today.

[1] "Nuclear Energy Centers: Industrial and Agro-Industrial Complexes," ORNL-4290. Oak Ridge National Laboratory, November 1968.

[2] Perry R. South, Potential Agricultural Production from Nuclear-Powered Agro-Industrial Complexes Designed for the upper Indo-Gangetic Plain," ORNL-4292. Oak Ridge National Laboratory, November 1968.

[3] "Nuclear Energy Centers: Industrial and Agro-Industrial Complexes: Summary Report," ORNL-4291. Oak Ridge National Laboratory, July 1968.

Egypt's current program for economic growth

The centerpiece of the current Egyptian development strategy as defined by the revolving five-year plan is the construction of eight 9We (gigawatt electrical) light water nuclear plants for power generation by the year 2000. The Egyptian Electricity Ministry is expected to begin taking bids for the first two plants in 1982. Over the past 12 months Egypt has signed agreements with the governments of the United States, France, Britain and West Germany to allow for the transfer of nuclear technology to Egypt.

According to projections from the Egyptian government, the eight plants will provide roughly half of the electricity demand by the year 2000. There are three sites for the plants, each site projected to handle up to four plants. Sidi Krier, 20 kilometers west of Alexandria, El Daba, 150 kilometers east of Alexandria (both on the Mediterranean), and Ras Zafararia, about 150 kilometers south of Suez on the Gulf of Suez, have been selected as sites.

El Daba will be the first to see nuclear plant construction, projected by the Cairo government to begin in 1983. Two plants are slated to be built there, to help power New Ameriya, a new city to be built west of Alexandria, and to supply electricity to a new ultra-high-technology integrated steel facility using the direct reduction process with Egyptian natural gas from the Abu Qir gas field.

Egypt's determination to acquire nuclear generating